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## Space Weather Technical Forecast

Issued on Sunday, 22 January 2023 at 01:07 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

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**Space Weather Forecast Headline: R1/R2 Radio Blackouts considered likely throughout. Chance of G1/Minor Geomagnetic Storms days 2 and 3 (23rd and 24th).**

### Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been Low through the past 24 hours, with only C-class flares, the largest was a C5 event observed at 21/2020 UTC. There are nine sunspot regions on the visible disc, with one new and unnumbered region emerging from around the northeast limb. AR3190 and AR3192 remain the largest and magnetically complex regions, with AR3190 containing a 'delta' spot configuration. All other regions are relatively small and appear to be stable. No Earth-directed CMEs have been observed in the past 24 hours.

**Solar Wind / Geomagnetic Activity:** Solar wind speeds, as measured at ACE, have been elevated to slightly elevated, with a peak 550km/s at 21/0908 UTC, before a gradual decline to near 450km/s. Density was above average through much of the period, falling below average by 21/1800 UTC. The IMF was generally steady at moderate levels initially, before becoming erratic and fluctuating between weak and moderate levels during the 21st, with a peak of 10 nT. The north-south component (Bz) was weak and erratic with a more prolonged spell of negative Bz between 21/0300-0600 UTC and reached -9 nT at 21/0716 UTC. The phi angle was rather erratic during the 21st. Geomagnetic activity was Quiet to Unsettled (Kp 0-3), with an Active (Kp 4) interval observed between 21/0300-0600 UTC.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) as measured at GOES-16 has been at Background levels throughout, with two minor proton responses to unknown events.

High energy electron flux (greater than 2 MeV) has been at background levels. The 24-hour integrated electron fluence stayed below the Active threshold on a downward trend, with 2.94e6 integrated pfu observed at 22/0001 UTC.

### Four-Day Space Weather Forecast Summary

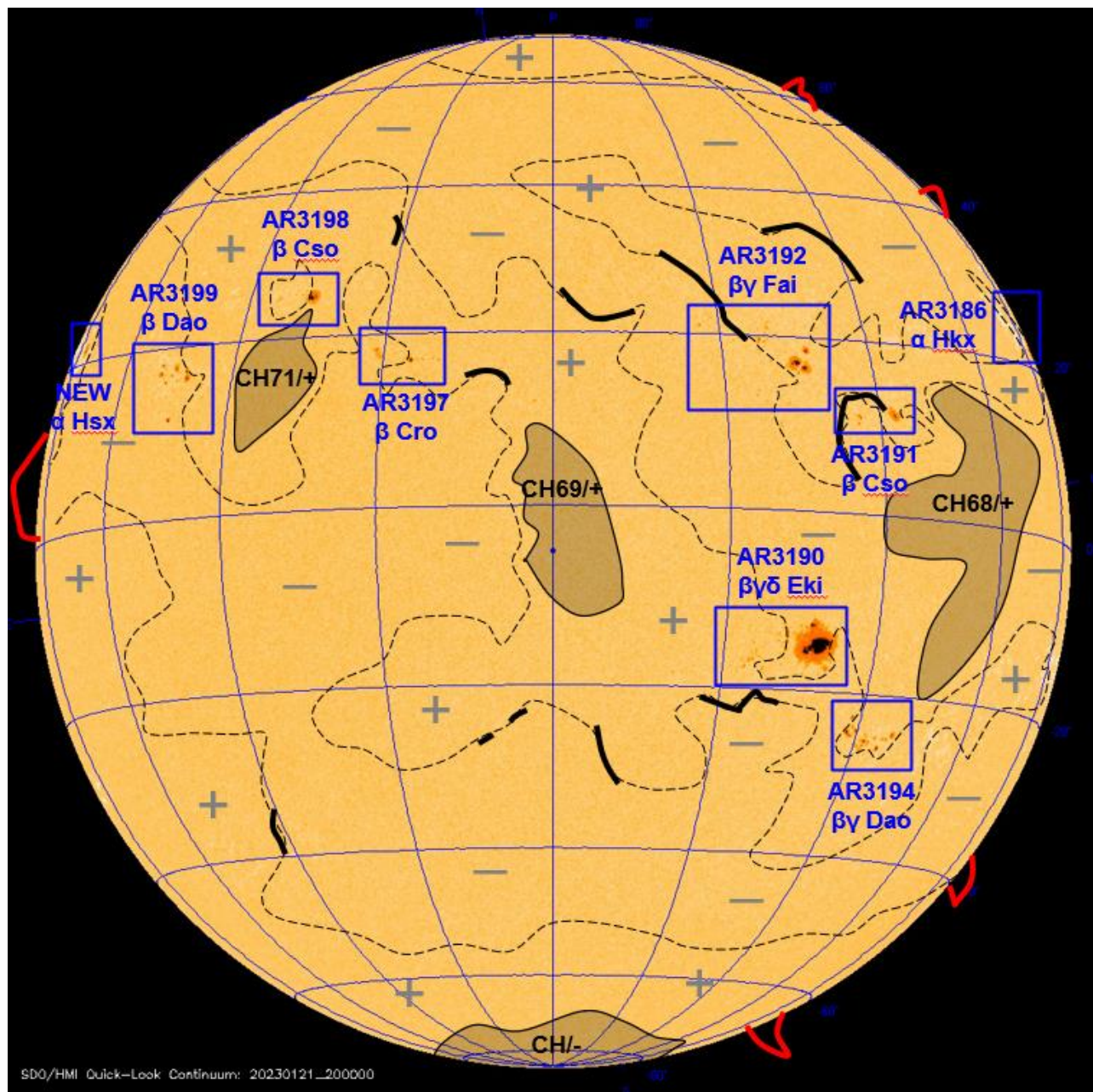
**Solar Activity:** Solar activity is likely to be Low or Moderate, with a slight chance of reaching High levels over the next four days. There are numerous regions on the disc, but the most obvious candidates for a significant flare remain AR3190 and AR3192.

**Solar Wind / Geomagnetic Activity:** The HSS from CH68/+ will likely continue to effect Earth during day 1 (22nd), though easing over time. Two CME's may effect Earth during day 2 (23rd), though both are low confidence. CH69/+ is likely to connect with Earth from day 3 (24th), with speeds of around 550 km/s expected. Generally Quiet to Active geomagnetic activity is expected through the period, with a slight chance of G1/Minor storms day 1 (22nd) due to HSS of CH68/+, then a chance of G1/Minor storms on days 2 and 3 (23rd and 24th) due to potential CME arrivals and then the HSS of CH69/+ respectively, with effects probably lasting into day 4 (25th), before gradually waning.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: [moswoc@metoffice.gov.uk](mailto:moswoc@metoffice.gov.uk)

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at predominantly background levels, but with a slight chance of reaching S1 or greater through the period. Electron flux should remain at background to moderate levels, although with a chance of rising to active during the diurnal peaks of days 1 and 2 (22nd and 23rd). Electron fluence is likely to stay below the Active threshold throughout the period, with perhaps a gradual rising trend by day 4 (25<sup>th</sup>).

**Figure 1. Solar Analysis Valid 21/2000 UTC.**



**Key:** Filament \_\_\_\_, Prominence \_\_\_\_, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson  $\alpha$ - $\beta$ - $\beta\gamma$ - $\beta\gamma\delta$  and Zurich-McIntosh Axx etc.

## Geomagnetic Storms:

Earth is currently in a weak HSS from CH68/+, which arrived during the morning of the 21st UTC, with a potential embedded weak transient CME. The effects of the HSS/CH68 will gradually wane during the 22nd.

Two CME's may effect Earth during the 23rd, the first from a faint halo signature associated with a flare from the NE on 19th. The second from a filament eruption from the SW on 20th, this may give glancing impacts, though both are low confidence.

CH69/+ located on the solar meridian is likely to connect with Earth during 24th, although this feature did not appear on previous rotation, therefore persistence is considered poor guidance. Speeds of around 550 km/s could be expected with this feature.

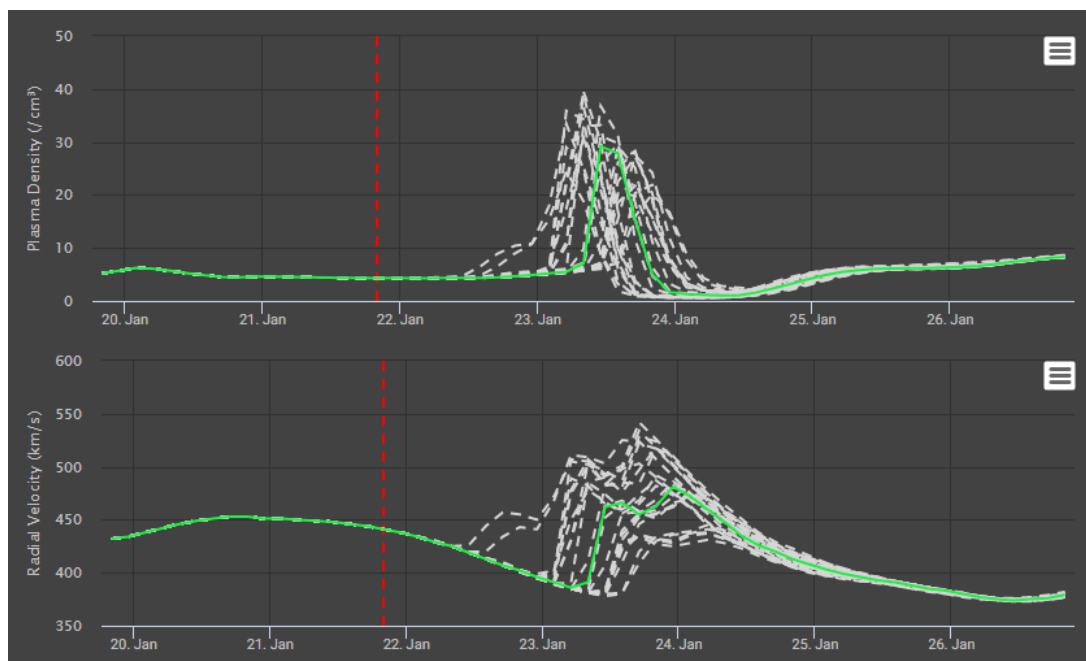
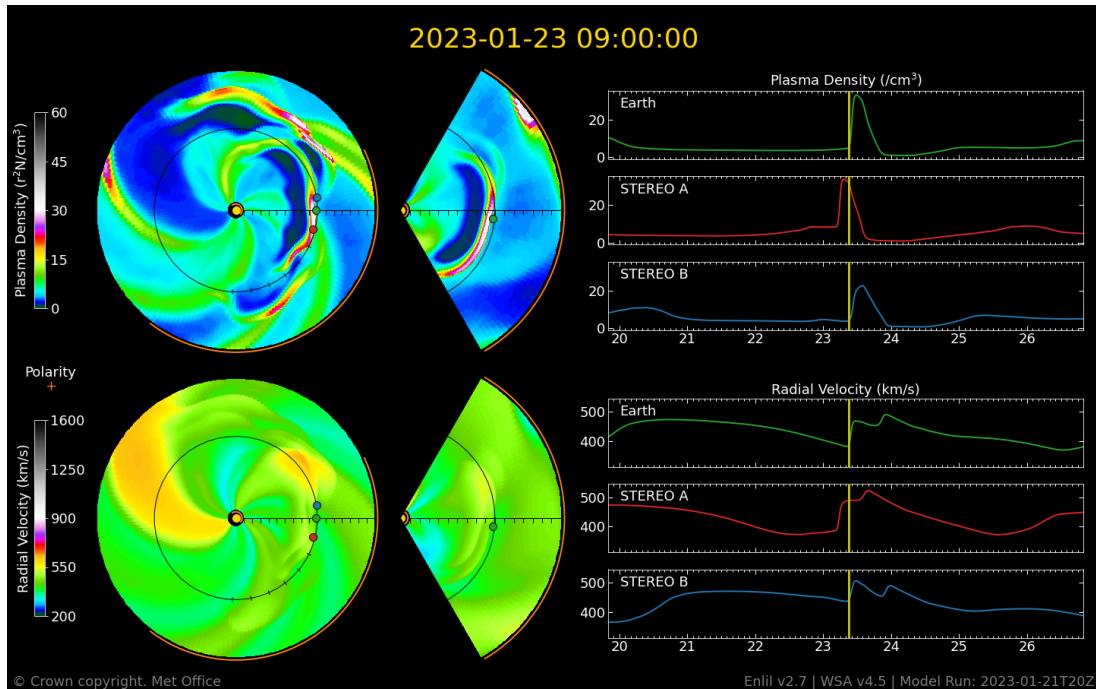
Generally Quiet to Active geomagnetic activity is expected through the period, with a chance of G1/Minor storms on days 2 and 3 (23rd and 24th) due to potential CME arrivals and the HSS of CH69/+ respectively, these effects will probably start to wane day 4 (25th).

| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | No                     | 5                 | 30                | 30                | 10                |
| Strong                   | G3       | No                     | 1                 | 1                 | 1                 | 1                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source            | Source Location | Estimated Speed | Estimated Arrival Time | Comments                                                 |
|-----------------------|-----------------------|-------------------|-----------------|-----------------|------------------------|----------------------------------------------------------|
| 20/0940               | Full                  | Filament Eruption | NE              | 500 km/s        | 23/0900                | Very faint, low confidence.                              |
| 20/1847               | Partial               | Filament Eruption | SW              | 770 km/s        | 23/1200                | Possible glancing blow, otherwise missing ahead of Earth |

**Figure 2: MOSWOC ENLIL and Ensemble (below) showing possible CME arrivals on the 23<sup>rd</sup>**



## Radio Blackouts - X-Ray Flares:

Solar activity has been Low through the past 24 hours, with only C-class flares observed. The largest was a C5 flare observed at 21/2020 UTC.

Solar activity is expected to be Low to Moderate, with a slight chance of reaching High levels throughout as the most complex regions continue to rotate west.

There are currently eight numbered and one un-numbered sunspot regions on the visible disc. AR3190 remains the largest and most complex, with some growth around its large leader spot, which contains a delta spot. AR3192 retains numerous spots and some magnetic complexity, but continues to show decay. Other regions are smaller and simpler, though the recent development of AR3199 in the northeast will continue to be monitored. A new and unnumbered sunspot region is emerging from around the northeast limb, although it's difficult to get an analysis due to foreshortening.

| X Ray Flares | Level               | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|--------------|---------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability  |                     |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active       | R1-R2<br>M Class    | No                        | 70                   | 70                   | 70                   | 70                   |
| Very Active  | R3 to R5<br>X Class | No                        | 10                   | 10                   | 10                   | 10                   |

**Figure 3: GOES-18 X Ray flares for past 24 hours.**

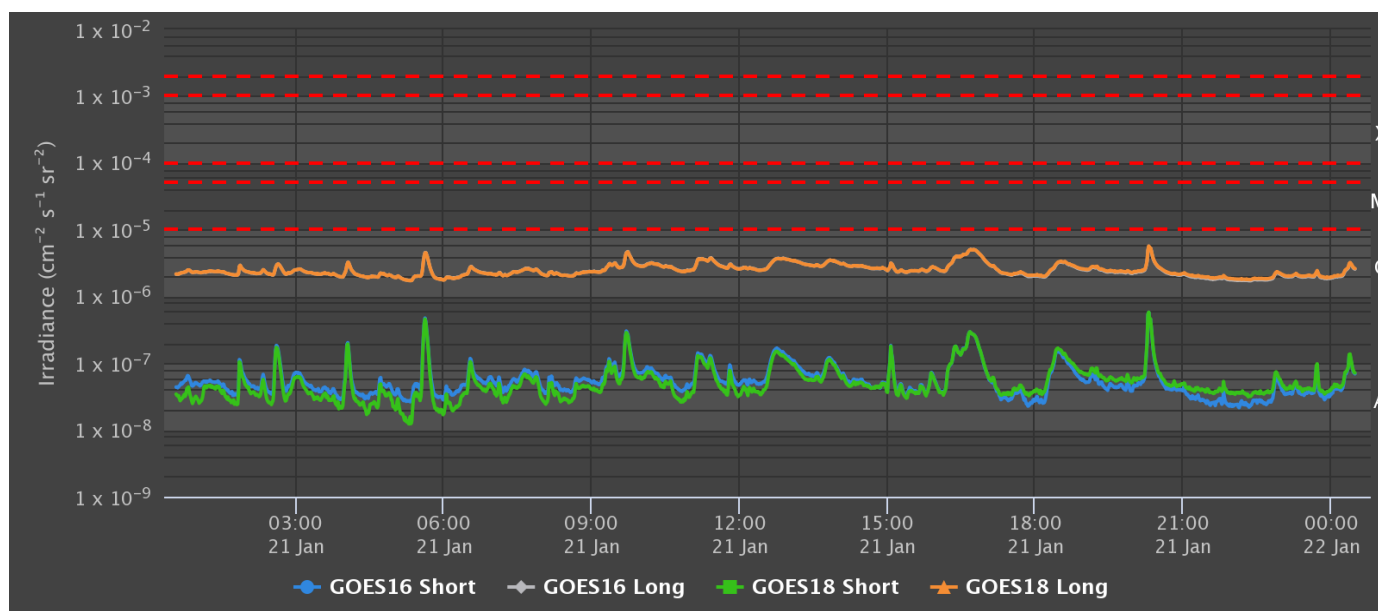
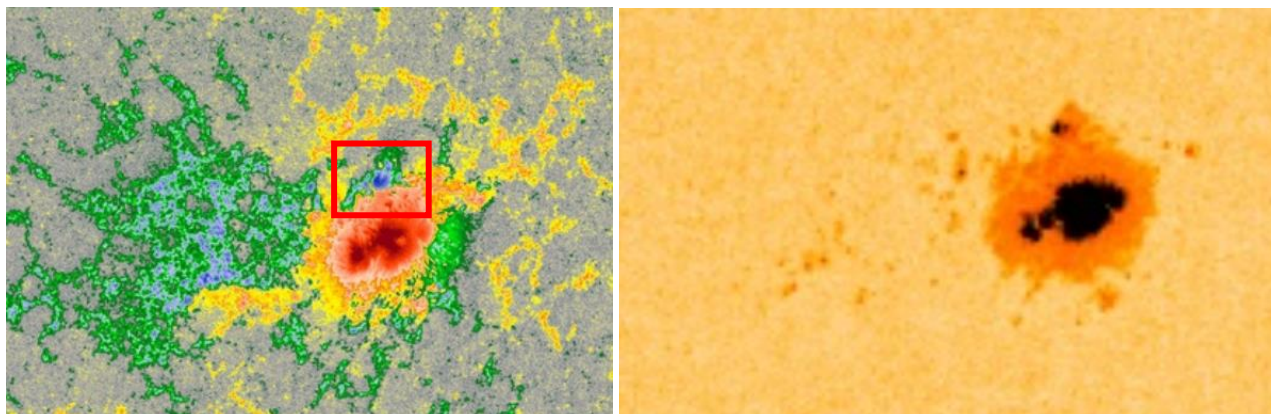


Figure 4: SDO/HMI magnetogram (left) and intensitygram (right) show AR3190 is a magnetically complex region and contains a 'delta' spot (red box).



## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at background levels. While no recent S1+ events have been observed at GEO, the sheer number of both front and far-sided complex groups dictates an elevated risk. Both AR3190 and AR3192 bring an increased risk as they continue to rotate westwards. As such, a slight chance of S1 or greater continues through the four day period.

| Radiation Storms                                                                                                                                             | Level<br>( $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance)                                                                                                                                  |                                                            |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                                                                                                                                                       | $\geq \text{S1}$                                           | No                        | 15                   | 15                   | 15                   | 15                   |
| Very Active                                                                                                                                                  | $\geq \text{S3}$<br>*                                      | No                        | 1                    | 1                    | 1                    | 1                    |
| * S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$ . (pfu = $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) |                                                            |                           |                      |                      |                      |                      |

## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

High energy electron flux remains at background to moderate levels. Electron flux should remain at background to moderate levels, although with a chance of rising to active during the diurnal peaks of days 1 and 2 (22nd and 23rd). Possible CMEs on the 23rd may act to redistribute the electron fields, therefore reducing the risk into days 3 and 4 (24th and 25th). Electron fluence is likely to stay below the Active threshold through the period. Perhaps a rising trend towards the end of the period, as HSS and CME effects begin to wane. The MOSWOC REFM model is considered as a good overall trend for the four day period.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|-----------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                           |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 5                 | 5                 | 10                | 20                |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |

Figure 5: MOSWOC REFM and observations

